

## PATENT ABSTRACTS OF JAPAN

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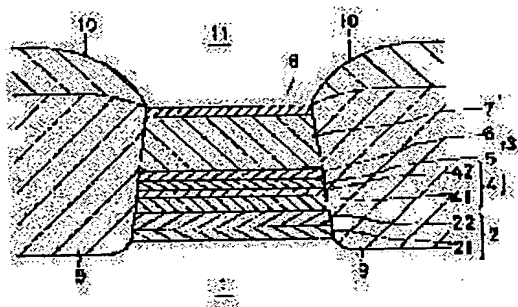
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(54) SPIN VALVE MAGNETORESISTIVE SENSOR AND THIN-FILM MAGNETIC HEAD

(57)Abstract:

**PROBLEM TO BE SOLVED:** To intensify (111) orientation of each film layer of a spin valve film, increase unidirectional anisotropic magnetic field, reduce the interaction magnetic field between both of the magnetic layers, obtain thermal and magnetic stability, and improve magnetic conversion characteristic, such as high change rate of magnetoresistivity and linearity of magnetoresistive change.

**SOLUTION:** A first base film 21 of nonmagnetic metal such as Ta and a second base film 22 of alloy formed thereon which alloy is expressed by  $\text{NiFeX}$  (X is at least one kind selected from among Cr, Nb and Rh) are formed on a substrate layer 2. A free magnetic layer 4 and a pin magnetic layer 6, which are arranged sandwiching a nonmagnetic conducting layer 5, and an antiferromagnetic layer 7 are laminated on the base layer 2, thereby forming a spin valve film 3. In a spin valve magnetoresistive sensor having the spin valve film 3, the second base film has an fcc structure and subjected to (111) orientation.



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CLAIMS

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[Claim(s)]

[Claim 1] One pair of magnetic layers arranged on both sides of a non-magnetic layer at said substrate layer and substrate layer top on a substrate, It is the spin bulb magnetic-reluctance sensor which carried out the laminating of the antiferromagnetism layer which adjoins said one magnetic layer. Said substrate layer The 1st substrate film of non-magnetic metal, The spin bulb magnetic-reluctance sensor which it consists of the 2nd substrate film of the alloy expressed with NiFeX (at least one sort as which X is chosen from Cr, Nb, and Rh) formed on said 1st substrate film, and said 2nd substrate film has fcc structure, and (111) is characterized by carrying out orientation.

[Claim 2] The spin bulb magnetic-reluctance sensor according to claim 1 characterized by being in within the limits whose thickness of said 2nd substrate film is 20-100Å.

[Claim 3] The spin bulb magnetic-reluctance sensor according to claim 1 or 2 characterized by being in within the limits said whose X is Cr and, the presentation of whose is 20 - 50at%.

[Claim 4] The thin film magnetic head equipped with a spin bulb magnetic-reluctance sensor according to claim 1 to 3 which comes out and is characterized by a certain thing.

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the magnetometric sensor and the thin film magnetic head using especially a spin bulb magneto-resistive effect about the magnetic-reluctance mold sensor used for a magnetic recording medium.

[0002]

[Description of the Prior Art] In order to make a saturation field small in the magnetic head for playback and to raise field sensibility recently, the magnetometric sensor which consists of spin bulb film of the sandwich structure which carried out the laminating of one pair of magnetic layers on both sides of the non-magnetic layer on the substrate is developed. To the spin bulb film being fixed in the component height direction by the switched connection field with the antiferromagnetism layer in which magnetization of one magnetic layer (pin layer) adjoins it, generally magnetization of the magnetic layer (free layer) of another side is single-domain-ized crosswise [ of a component / truck ] by the hard bias method using the field of a permanent magnet, and rotates freely by the external magnetic field.

[0003] The linearity of the magnetic response to an external magnetic field is secured, and the magnetic properties of a magnetometric sensor improve, so that a pin layer can be single-domain-ized good, so that the one direction anisotropy magnetic field by the antiferromagnetism layer is large, and the magnetization is fully fixed. Then, more various antiferromagnetism ingredients than before are proposed. Moreover, as for the antiferromagnetism ingredient, it is known that a property will change with the ingredients of the substrate.

[0004] For example, the magneto-resistive effect head which can raise properties, such as magnetic-reluctance rate of change, is indicated by JP,8-315326,A by arranging the crystalline soft magnetism film which may raise a stacking tendency by high resistance as a substrate of the magneto-resistive effect film. Furthermore, according to this official report, in order to raise the crystallinity of said crystalline soft magnetism film, preparing non-magnetic metal film, such as Ta, in the substrate is indicated. Moreover, in order to arrange the crystal orientation of a magnetic free layer, Ta substrate layer is used for the magnetic-reluctance sensor indicated by JP,8-213238,A.

[0005] Furthermore, it is indicated by JP,9-16915,A by using the two-layer film of Ta film and the NiFe system alloy film as a substrate layer in spin bulb magnetic-reluctance mold tolan DEYUSA that the crystallinity of an antiferromagnetism layer is improved, magnetization of a pin layer is fully fixed, and a linearity magnetic-reluctance change can be obtained. Moreover, in the magneto-resistive effect component, while improving the orientation (111) of the ferromagnetic formed on it by the substrate layer of the two-layer structure which has arranged the 2nd substrate film, such as Ta, between the 1st substrate film of an ingredient and substrates which have an fcc lattice, it is indicated by JP,6-325934,A that surface smooth nature can be improved.

[0006]

[Problem(s) to be Solved by the Invention] However, by the spin bulb film which prepared the substrate layer which consists of the conventional Ta film, since a limitation usually had an one direction anisotropy magnetic field by the antiferromagnetism layer by 200 to 1000 oersted (Oe), when this was applied to the magnetic head, when operating temperature became high, the magnetization direction of a pin layer changed, the magnetic transfer characteristic became unstable, and there was a possibility of spoiling dependability.

[0007] Moreover, in a spin bulb magnetic-reluctance sensor, when the free layer was made thin, the playback output could be made high, but when the thickness exceeded a certain limitation (about 30-40Å), the orientation (111) of a free layer became inadequate, the ferromagnetism-interaction between a free layer and a pin layer became large, the playback output declined conversely, and there was a problem of becoming unstable magnetically. Therefore, although the thickness of a free layer is usually set up within the limits of about 50-100Å, in order to make a playback output high, it is desirable [ securing magnetic stability ] that thickness of a free layer can be made as thin as possible.

[0008] Then, the place which it is made in view of the conventional trouble mentioned above, and is made into the purpose has this invention in enlarging the one direction anisotropy by the antiferromagnetism film of the spin bulb film, and making small the interaction between a free layer and a pin layer, and offering the spin bulb magnetic-reluctance sensor which stabilized the magnetic transfer characteristic thermally and magnetically.

[0009] Moreover, another purpose of this invention is by having this spin bulb magnetic-reluctance sensor to offer the thin film magnetic head of the high performance which can attain good recording density-ization.

[0010]

[Means for Solving the Problem] In order to attain the purpose mentioned above according to this invention, on a substrate A substrate layer, It has the spin bulb film which carried out the laminating of one pair of magnetic layers arranged on both sides of a non-magnetic layer on said substrate layer, and the antiferromagnetism layer which adjoins said one magnetic layer. Said substrate layer The 1st substrate film of non-magnetic metal, It consists of the 2nd substrate film of the alloy expressed with NiFeX (at least one sort as which X is chosen from Cr, Nb, and Rh) formed on said 1st substrate film. Said 2nd substrate film has fcc (face centered cubic) structure, and (111) the spin bulb magnetic-reluctance sensor characterized by carrying out orientation is offered.

[0011] While the orientation (111) of the crystal face becomes strong and an one direction anisotropy magnetic field becomes large by forming both the magnetic layers, non-magnetic layer, and antiferromagnetism layer of the spin bulb film on such 2nd substrate film, the interaction magnetic field between both magnetic layers becomes small. The spin bulb magnetic-reluctance sensor which this shows high magnetic-reluctance rate of change and a linearity magnetic-reluctance change is obtained.

[0012] The crystal stacking tendency of the spin bulb film cannot improve more than a certain extent, even if it thickens thickness of a substrate layer too much. As for the thickness of the 2nd substrate film, it is desirable that it is within the limits of 20-100A.

[0013] Moreover, by choosing suitably the concentration of the element X contained in NiFeX, a substrate layer can be made nonmagnetic rather than the case of a NiFe alloy, and can be formed into high resistance, can lessen the shunt current to a substrate layer sharply, and can raise the reluctivity of a sensor. If it is in within the limits whose element X is Cr and the presentation of whose is 20 - 50at% especially, since-izing of the magnetism of NiFe which constitutes the 2nd substrate film can be disappeared and carried out [ nonmagnetic ], it is convenient.

[0014] Furthermore, according to another side face of this invention, by having the spin bulb magnetic-reluctance sensor mentioned above, it has high stability thermally and magnetically and the possible thin film magnetic head of high recording density is offered.

[0015]

[Embodiment of the Invention] Drawing 1 shows the suitable example of the spin bulb magnetic-reluctance sensor which applied this invention. The substrate layer 2 is formed on the alumina (aluminum 2O3) insulating layer 1 prepared on the substrate with which this spin bulb magnetic-reluctance sensor consists of ceramic ingredients, such as glass, silicon, aluminum 2O3, and TiC, and the laminating of the magnetic-reluctance (MR) film 3 of spin bulb structure is carried out on it. The substrate layer 2 of this example is two-layer structure with the 2nd substrate film 22 which consists of the 1st substrate film 21 and the nickel-iron-chromium (NiFeCr) with a thickness of 50A which consist of a tantalum (Ta) with a thickness of 30A.

[0016] The MR film 3 Nickel-iron with a thickness of 50A which carried out the laminating on the substrate layer 2 (NiFe) the film — 41 — thickness — ten — A — cobalt — iron (CoFe) — the film — 42 — two-layer — structure — from — becoming — free — a magnetic layer — four — thickness — 25 — A — copper — (— Cu —) — the film — from — becoming — nonmagnetic — a conductive layer — five — thickness — 20 — A — cobalt — iron (CoFe) — the film — from — becoming — a pin — a magnetic layer — six — And it has the antiferromagnetism layer 7 which consists of platinum-manganese (PtMn) film with a thickness of 300A. On the MR film 3, it adheres to the protective layer 8 which consists of Ta film with a thickness of 30A.

[0017] The both sides of the MR film 3 are removed by etching according to the predetermined width of recording track, and the hard bias layer 9 is formed. On the hard bias layer 9, one pair of electric conduction leads 10 are formed as an electrode for passing a sense current, the whole laminated structure of a parenthesis is further covered with the alumina insulating layer 11, and the spin bulb MR sensor of this invention is completed.

[0018] By performing heat treatment predetermined in the inside of a vacuum magnetic field after membrane formation, the MR film 3 makes the antiferromagnetism layer 7 regulation-ize, and, on the other hand, gives a tropism anisotropy to the pin magnetic layer 6, and fixes the magnetization orientation. The 2nd substrate film 22 of NiFeCr has the fcc crystal structure, and (111) since orientation is carried out, it can raise on it the stacking tendency (111) of each class of the MR film 3 which carries out a laminating. Thereby, the one direction anisotropy magnetic field according [ said MR film ] to the antiferromagnetism layer 7 becomes large, and the interaction magnetic field between the free magnetic layer 4 and the pin magnetic layer 6 becomes small.

[0019] In the 2nd substrate film 22, Cr concentration of said NiFeCr film has the desirable range of 20 - 50at%, in order to make high resistance form, nonmagnetic-izing and. The thickness of the 2nd substrate film 22 is not limited to 50A mentioned above, but can be suitably set up within the limits of 20-100A. Moreover, the NiFe system alloy which added Nb(s) other than Cr, Rh, etc. can be used for NiFe as an ingredient of said 2nd substrate film. Since the shunt current to a substrate layer can be controlled by choosing the high presentation of specific resistance in any case, big magnetic-reluctance rate of change is obtained.

[0020] Said both magnetic layers can be formed with conventionally well-known various ferromagnetic ingredients, such as Co and CoFeB, in addition to Above NiFe and CoFe, and various antiferromagnetism ingredients, such as the PdPtMn system known from the former in addition to PtMn mentioned above, a NiMn system, an IrMn system, a RhMn system, a FeMn system, and a NiO system, can be used for said antiferromagnetism layer.

[0021] another example — the example of drawing 1 — reverse — the antiferromagnetism layer 7 — a substrate side — and the laminating of each membrane layer can be carried out to reverse order by using the free magnetic layer 4 as a substrate in the opposite side. Also in this case, the same operation effectiveness as the example of drawing 1 is acquired. Moreover, this invention can add and carry out other various deformation and modification in the above-mentioned example within the technical limits.

[0022] Drawing 2 is the thickness  $t_2$  of the 2nd substrate film 22 of the presentation which consists of NiFe16Cr25 in the example of drawing 1. The stacking tendency (111) of the NiFe film 41 of the PtMn antiferromagnetism layer 7 about change and the free magnetic layer 4 is shown. This X-ray diffraction profile shows that the stacking tendency with said both strong (111) membrane layers is shown in general within the limits of  $20 \leq t_2 \leq 50$ .

[0023] moreover, the example of drawing 1 — setting — thickness  $t_1$  of the 1st substrate film 21 of Ta Interaction magnetic field Hint between the switched connection magnetic field Hex about the thickness  $t_2$  of the 2nd substrate film 22 of presentation NiFe16Cr25, and a pin layer / free-similarly layer when it considers as 30A, 15A, and 0A the place which measured change — drawing 3 R > 3 — the result shown in A and B was obtained. For drawing 3 A, the switched connection magnetic field Hex is thickness  $t_1$ . Irrespective of magnitude, it is shown that a large value is shown in general within the limits of  $20 \leq t_2 \leq 50$ , therefore an one direction anisotropy becomes large. On the other hand, drawing 3 B is the interaction magnetic field Hint. Becoming small within the limits of  $20 \leq t_2 \leq 50$  in general similarly is shown.

[0024] Furthermore, it sets in the example of drawing 1 and is the thickness  $t_1$  of the 1st substrate film 21 of Ta. It is the thickness  $t_2$  of the 2nd substrate film 22 of presentation NiFe16Cr25 the same, when it presupposes that it is fixed and the MR film 3 is heat-treated at 250 degrees C and 270 degrees C. When change of the interaction magnetic field Hint between the related pin layer / free layer was measured, the result shown in drawing 4 was obtained. It also sets to which heat treatment temperature, and this drawing is the interaction magnetic field Hint. Becoming small within the limits of  $20 \leq t_2 \leq 70$  in general is shown. From these measurement results, the operation effectiveness which this invention mentioned above was checked.

[0025]

[Effect of the Invention] Since this invention is constituted as mentioned above, it does so effectiveness which is indicated below. Since according to the spin bulb magnetic-reluctance sensor of this invention orientation (111) of the spin bulb film is strengthened with the 2nd substrate film, an one direction anisotropy magnetic field is enlarged and the interaction magnetic field between both magnetic layers can be made small, high stability is acquired thermally and magnetically and improvement in the magnetic transfer characteristics, such as high magnetic-reluctance rate of change, the high linearity of magnetic-reluctance change, etc., can be attained. furthermore — thereby — thermal — magnetic — high stability — having — high — recording density — the magnetic head [— izing / the magnetic head ] is realizable.

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] It is the sectional view which looked at the suitable example of the spin bulb magnetic-reluctance sensor by this invention from the ABS side.

[Drawing 2] It is the diagram showing the X-ray diffraction profile which expresses the stacking tendency (111) of the NiFe film of the PtMn antiferromagnetism layer about the thickness of the 2nd substrate film of NiFeCr, and a free magnetic layer, respectively.

[Drawing 3] A Fig. and B Fig. are the switched connection magnetic field Hex about the thickness of the 2nd substrate film of NiFeCr, and the interaction magnetic field Hint between a pin layer / free layer, respectively. It is the diagram showing change.

[Drawing 4] Interaction magnetic field Hint between the pin layer / free layer about the thickness of the 2nd substrate film of NiFeCr at the time of heat-treating MR film at 250 degrees C and 270 degrees C, respectively It is the diagram showing change.

[Description of Notations]

- 1 Insulating Layer
- 2 Substrate Layer
- 3 MR Film
- 4 Free Magnetic Layer
- 5 Nonmagnetic Conductive Layer
- 6 Pin Magnetic Layer
- 7 Antiferromagnetism Layer
- 8 Protective Layer
- 9 Hard Bias Layer
- 10 Electric Conduction Lead
- 11 Alumina Insulating Layer
- 21 1st Substrate Film
- 22 2nd Substrate Film
- 41 Nickel-Iron Film
- 42 Cobalt-Iron Film

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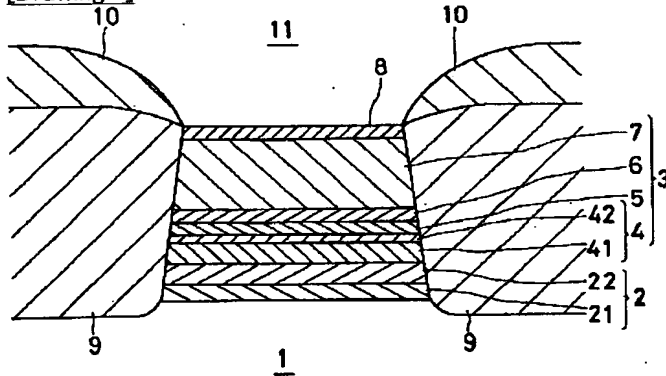
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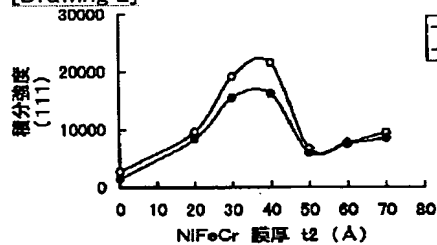
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## DRAWINGS

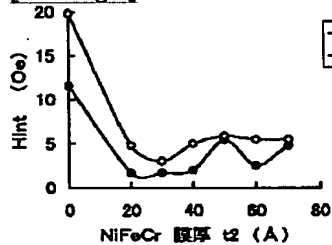
[Drawing 1]



[Drawing 2]

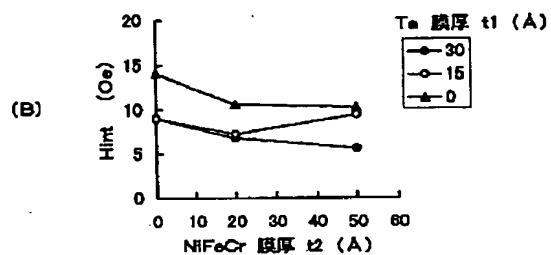
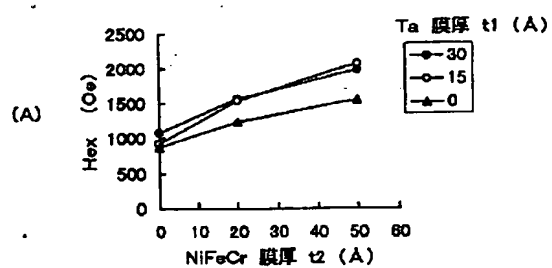


[Drawing 4]



[Drawing 3]





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